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Published in:

MobileHCI '12 Proceedings of the 14th international conference on Human-computer interaction with mobile devices and services

DOI (link to publication from Publisher):

[10.1145/2371574.2371609](https://doi.org/10.1145/2371574.2371609)

Publication date:

2012

Document Version

Early version, also known as pre-print

[Link to publication from Aalborg University](#)

Citation for published version (APA):

Grubert, J., Morrison, A., Munz, H., & Reitmayr, G. (2012). Playing it Real: Magic Lens and Static Peephole Interfaces for Games in a Public Space. In *MobileHCI '12 Proceedings of the 14th international conference on Human-computer interaction with mobile devices and services* (pp. 231-240). Association for Computing Machinery. <https://doi.org/10.1145/2371574.2371609>

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Playing it Real: Magic Lens and Static Peephole Interfaces for Games in a Public Space

Jens Grubert¹, Ann Morrison², Helmut Munz³, Gerhard Reitmayr¹

¹Institute for Computer Graphics and Vision
Graz University of Technology, Austria
[grubert | reitmayr]@icg.tugraz.at

³haellmuth@gmail.com

²Department of Architecture, Design
and Media Technology
Aalborg University
DK-9220 Aalborg Øst
ann.morrison@acm.org

ABSTRACT

Magic lens and static peephole interfaces are used in numerous consumer mobile phone applications such as Augmented Reality browsers, games or digital map applications in a variety of contexts including public spaces. Interface performance has been evaluated for various interaction tasks involving spatial relationships in a scene. However, interface usage outside laboratory conditions has not been considered in depth in the evaluation of these interfaces.

We present findings about the usage of magic lens and static peephole interfaces for playing a find-and-select game in a public space and report on the reactions of the public audience to participants' interactions.

Contrary to our expectations participants favored the magic lens over a static peephole interface despite tracking errors, fatigue and potentially conspicuous gestures. Most passersby did not pay attention to the participants and vice versa. A comparative laboratory experiment revealed only few differences in system usage.

Author Keywords

Augmented Reality; Static Peephole; Magic Lens; Field Trial

ACM Classification Keywords

H5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous; H.5.2 [Interfaces and Presentation]: User Interfaces - Benchmarking

General Terms

Performance; Design; Experimentation; Human Factors

INTRODUCTION

The increasing processing power of sensor equipped smartphones along with the increasing usage of state of the art vision and machine learning algorithms in mobile phone

applications give rise to mobile users being confronted with relatively novel interface metaphors such as gestural [19], speech [9] or magic lens (ML) interfaces [2]. Specifically in mobile handheld Augmented Reality (AR) systems the ML metaphor is employed by relating information to physical objects or locations on the screen of the mobile device.

Static peephole (SP) [16] [31] interfaces are integrated into various map-based applications on mobile devices for years. On multi-touch enabled smartphones they make use of surface gestures such as drag-to-pan and pinch-to-zoom to navigate in a virtual space. With SP interfaces users can hold the phone proximate to their bodies, allowing use in a variety of situations while walking, standing or sitting. In contrast, ML interfaces require users to align the orientation of the device with the physical object (reference frame) to be augmented during the whole time of interaction.

While performance comparisons between ML, SP and dynamic peephole (DP) interfaces have been carried out in laboratory settings relatively few studies investigated user adoption of these interfaces in public contexts [17] [18]. For example, it is not yet well explored how potentially more visible gestures that are part of ML usage (while still unfamiliar to the general public) influence the adoption of this interface.

Within this paper our main research interests are to explore *if and how* people would use a ML interface for a mobile game in a public location when a SP interface is available as alternative, to gauge the *reactions from the general public* and to determine the *impact of location and audience on task performance*.

Therefore, we designed a mobile phone game that could be played at a poster mounted at a public building in a transit area or on the smartphone alone but at the same location. We complemented the observations at the public space with observations of a separate group conducting the same tasks in a controlled laboratory setting.

With this work we add insights about user and audience behavior when using a ML interface outside the laboratory and complement existing studies that investigated collaborative use of mobile AR systems in the wild.

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MobileHCI'12, September 21--24, 2012, San Francisco, CA, USA.
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RELATED WORK

The performance of ML, SP and DP interfaces was thoroughly investigated under laboratory conditions in various works. Rohs et al. compared users' performance in a find-and-select task for ML, DP and SP interfaces [26] and showed that ML and DP pointing outperformed joystick-based SP pointing. They also investigated the impact of item density and visual context [23] on ML and DP pointing and proposed a two-phase adaption to Fitt's law which they evaluated in laboratory [24] and real world settings [25].

Due to the limited screen space on mobile devices various off-screen visualization techniques have been proposed for SP interfaces [1] [4] [8]. Off-screen visualization for ML interfaces can be split into ones indicating target regions if the reference frame is a planar target in front of the user [10] and ones that indicate a target around users that is inside the same reference frame as the users [3]. While we do not use off-screen visualizations in our system, the trends to conduct studies in the field [11] [28] encouraged us to study potential effects that might not be observed in laboratory settings such as the influence of the audience on system usage.

Social interactions at public displays or interactive installations have been investigated in several approaches (e.g., [13] [14] [21]). The combination of private and public displays was also examined for example, by looking at how to initiate connections between devices [15]. However, relatively few approaches considered social aspects when interacting with novel gestures and postures on handheld devices in public spaces.

One of the first works that evaluated a handheld ML interface in a museum setting was described in [27]. While the authors concentrated on the technical feasibility of the system they also investigated the use of handheld AR systems for short games (2-3 min each). In particular the authors found that while the motivation of children was generally high, tasks involving AR had to be explained in detail.

In an online survey Rico and Brewster evaluated the social acceptability of device and body based gestures [22] for different locations and audiences and complemented it with field trials in a private and a public setting. However, they did not specifically consider the use of ML and peephole interfaces.

Morrison et al. conducted field trials on the collaborative use of handheld ML and SP interaction with a single device in each group [18] and later expanded to synchronous use of multiple mobile devices [17]. One observation from these trials was that users of ML concentrated more on the interface and the game whereas SP users were more aware of their environment. In contrast to these studies we are focusing on single user adoption of ML and SP interfaces in a public setting in a non-collaborative task while taking into account reactions from the public.

We add to previous studies by investigating how people would use a ML and SP interface with a vertical reference frame (poster) in a public setting and what the influence of location and audience is on task performance.

GAME DESIGN AND IMPLEMENTATION

Find-and-select tasks are common in mobile AR games. Users are required to physically translate (pan and zoom) and eventually rotate their phones in order to detect targets; selection is typically accomplished through touching the screen. While mobile AR games often employ only a ML interface to solve the task, mobile AR browsers offer alternative list and SP views on the data. SP interfaces for smartphones allow navigation through dragging (pan) and pinching (zoom).

We wanted to observe how users would adapt to ML and SP interfaces if they can solve a task with either interface in a public space. We decided on a simple find-and-select task similar to previous performance-centric studies [10]. To engage people over an extended period of time at one location, we designed a game-like experience with background music, audio, graphical effects and challenges. Each level lasted approximately one to two minutes; playing 8 consecutive levels could eventually lead to fatigue. The game could be played with a ML and with a SP interface (see Figure 1) that showed similar views on the game to lower the mental gap when switching between them. The interaction methods to find the targets were different between the interfaces (physical pointing in ML, drag-to-pan and pinch-to-zoom in SP). Selection was accomplished by clicking in either interface. The poster as reference frame for the game was available in both interfaces (physical for ML, virtual for the SP). The field of view of the virtual camera was set to match the one of the physical camera. For the game we did not focus on collaborative activities. Instead, the game tasks required the players to repeatedly find a 'moving worm' that could appear at one of 20 locations (apples on a tree) in two possible sizes. Individual targets had to be selected three times before appearing elsewhere.

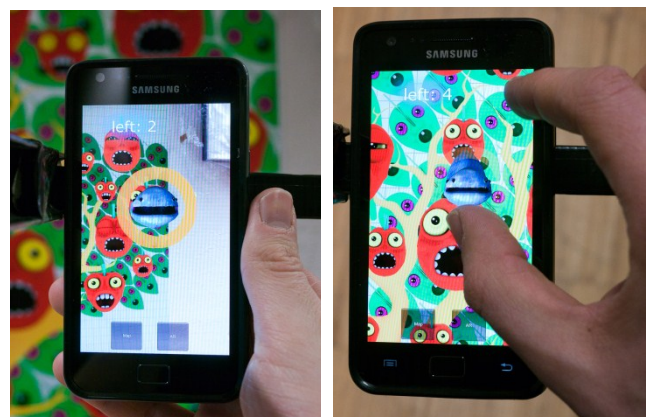


Figure 1. A large target within selection distance (indicated by orange ring) in the magic lens view (left). User pinching to zoom in to a small target in the static peephole view (right).



Figure 2. A participant playing the game in front of the poster at the public transit place in Graz, Austria.

To select the targets, users had to be in a minimum distance in front of the target (ca. 30 cm for a small target, ca. 60 cm for a large one) forcing them to physically move back and forth with the ML interface or to pinch in and out in the SP interface.

Users could explicitly switch between the interfaces by pressing buttons at the bottom of the screen which would show the closest orthogonal view of the virtual poster when switching from ML to SP. When users pointed their phone down they implicitly switched into a standard view (showing approximately 2/3 of the virtual poster.)

The levels did not increase in difficulty to observe possible learning and fatigue effects; only the positions and sizes of the worms were varied randomly. There were 8 levels in total, each with 15 targets to be played. Through pre-experiments we adopted parameters for dragging and pinching speeds, the default scale for the virtual poster and the minimum distances for target selection to ensure comparable times in both interfaces for a trained user.

The game was implemented in Unity with Qualcomm's Vuforia toolkit and deployed on a Samsung Galaxy SII smartphone running Android 2.3.

STUDY DESIGN

We designed an outdoor study and replicated a comparative indoor study to act as a control group. The outdoor study took place at a building below a large video wall on a central place in Graz, Austria (see Figure 2). The place serves as the main transit zone of the town to change public transportation lines and acts as a waiting area. In addition, musicians or advertisers can often be found here. Participants conducted the study in front of a DIN A0 sized poster that was mounted vertically at a height of 2 m. The control study took place inside a laboratory at Graz University of Technology (see Figure 3). Both the laboratory and outdoor studies took approximately one hour per participant and all participants were taken through the sequences by the same one researcher in the interests of consistency.



Figure 3: Participant playing the game in the laboratory.

There were 6 phases: introduction (5 min), training (5-10 min), demographic questionnaire (5 min), main game (15-20 min), interviews and questions (10-15 min) and performance (10-15 min). In the initial training phase the participants were made comfortable with both interfaces to a level where they could explicitly and implicitly switch between the two. They also learnt how to easily recover from tracking failures that could appear in the ML condition (e.g., due to fast movements or being too close to the poster, see Figure 4, left). As it was very cold (at times even down to -10°C , regardless, we witnessed people standing outside waiting for friends) after the training phase, participants filled out a demographic questionnaire in a nearby café.

In the main phase they were asked to select fifteen worms in 8 levels each. Participants were free to choose their preferred interaction technique. This was explained clearly in the training phase and again in the transition to the main phase. In addition, it was made clear they could switch interfaces as often as they liked, there were no restrictions on this. Participants were asked to complete the tasks but we clearly emphasized that their target focus was not speed or precision. Participants could set their own pace, taking breaks between the levels as they wished, with warm tea on hand.

The main phase was followed by a questionnaire and interview session in the same café where the demographic questionnaire was filled out. Finally, a performance phase was conducted at the poster similar to the one described by Henze et al. [10]. Participants had to find-and-select the bluest out of 12 boxes ranging from green to blue by panning and touching at a fixed distance (showing approximately 1/4 of the search area) 15 times in 4 repetitions resulting in 480 measurements per group and interface (see Figure 4, right). Participants were checked for color blindness before starting this test. This time they could only use *either* the SP or the ML interface at any one time. This meant that half of the participants started with the ML mode and then conducted the task in the SP mode, while the other half started with SP and then used the ML mode to ensure a balanced sample.

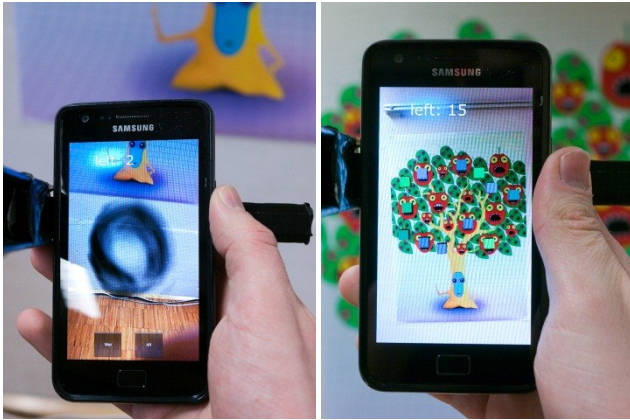


Figure 4. Tracking errors indicated by black circle in the middle of the screen (left). Overview of one configuration of colored target boxes in the performance phase (right).

Further, a control group of eight participants conducted the exact same procedure from beginning to end, including the initial training and performance phases, but in an indoor laboratory setting. The laboratory setting did not have passersby, only each participant and the experimenter were present. The poster was mounted on the same height as in the public condition.

Participants

There were 16 participants in total (8 female, 8 male) evenly distributed between the study at the laboratory and at the outdoor location. In both groups participants were aged between 21 and 30 years. All of them had either a university degree or were studying. Five people in the public location group had a computer science, two a design and one a social science background. In the laboratory group four people had a computer science, three a design, and one a mathematical background. Thirteen of 16 participants were familiar with the idea of AR, or had used AR at least once, regularly or professionally. All but one participant never to rarely (at most 1 hour per week) played video games and all but one never played video games on mobile devices.

Hypotheses

We followed an exploratory approach for the main part of the study to obtain insights into how the participants would employ the system and how the public would react to the interactions of the participants, specifically with the ML interface. Nonetheless, we had the following two hypotheses: *H1: ML will be used less often in the public setting than in the laboratory.* We suspected that playing the game in the ML interface would cause more attention from the public and that participants would feel exposed and watched, eventually switching to the less obtrusive SP interface in the public setting. *H2: ML will be used less as the game progresses.* As the game levels were repetitive and the main phase was expected to last for 15-20 minutes we suspected that as arm fatigue increases and the novelty of the ML interface decreases participants would eventually switch to SP.

Data Collection

We collected video, survey and device logging data, complemented with notes, stills and additional videos taken by one observer. Quantitative data was analyzed with Microsoft Excel and the R statistical package. Null hypothesis significance testing (NHST) was carried out with the 0.05 level.

Video Data

A small camera with a wide angle lens (100° diagonal field of view) was vertically mounted next to the poster (behind a pillar in the public condition), which recorded participants' actions and the reactions from the public during the main task. In addition an observer took notes and additional footage with another camera. In total 2 hours of video footage (only for the main game phase) was collected for the public condition and processed by a single coder.

Survey Data

We employed questions that are based on Flow [30], Presence [29] and Intrinsic Motivation [5] research and were adapted through a series of studies [13, 17, 18]. We customized them for this study to capture reactions on the system and tasks in the environment using a 5-point Likert scale. A multiple choice questionnaire similar to [22] about location and audience was used and followed by a semi-structured interview focusing on how participants used the system and how they would use it in other settings.

Device Data

The position of the real camera (in ML) or the virtual camera (SP) mode was sampled at 10 Hz. Additionally, events such as touches, interface switches, task completion times (TCTs) interface were logged on the device. The timing data was not normal distributed so non-parametric NHST was applied. One participant in the public location had to abort the main phase after 6 of 8 levels but eventually continued with the performance phase.

Limitations

While we employ NHST, we stress that with our limited sample size the results are particular to this situated instance. Further exploration with a larger sample in a wider variety of settings is required prior to being able to make any generalizations from our findings. As with many mobile trials conducted in a public space, the setting and tasks are generally somewhat contrived with participants aware that they are taking part in a study where they are accountable to the researcher team while doing tasks designed to test unknown (to them) research-related criteria.

FINDINGS

We report on our observations combining quantitative and qualitative results as well as findings from the public and the laboratory setting where appropriate for our limited sample size.

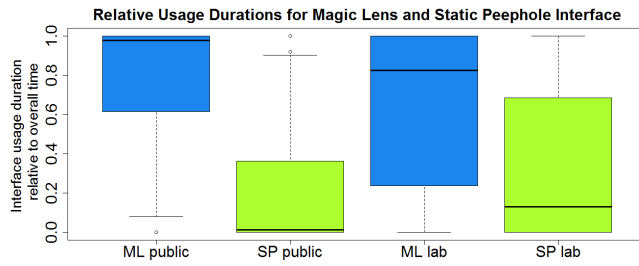


Figure 5. Relative usage duration for the magic lens (blue) and static peephole (green) interface in the public and lab condition.

Magic Lens was used most of the Time

The ML interface was used 72% of the time (76% in the public setting, 68% in the lab) as illustrated by Figure 5. The ML interface was used weak significantly longer in the public setting than in the lab condition as indicated by a Mann-Whitney U test ($p = 0.056$, $Z = -1.59$). The significant difference is due to one participant playing solely in SP mode in the lab condition. But even with considering this one participant as an outlier (resulting in no significant difference in usage time of ML between both locations) our hypothesis *H1* that the ML interface would be used less in the public setting is contradicted. Figure 6 shows boxplots of the absolute TCTs over all levels.

A Mann-Whitney U test indicated no significant differences for completion times over all levels between the groups. In addition, a Friedman rank sum test did not reveal significant differences for ML usage duration between the 8 levels for the public location and for the lab group, thus contradicting hypothesis *H2* that the ML interface would be used less as the game progresses. Figure 7 shows the relative usage duration of the ML interface over 8 levels in the public location group.

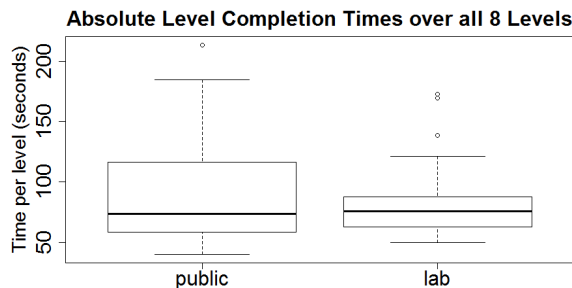


Figure 6. Absolute level completion times for the public and lab group.

Spatial Configurations for Magic Lens Usage

Generally, participants switched between a position in which they could get an overview about the whole poster to identify the target and then moved in to select the target.

We observed diverse ways of how participants handled the fact that they needed to move back and forth during the game and the holding of the phone itself. All but one participant used a relative fixed arm pose and moved using their feet, stretching their arms only for the last few inches towards the poster.

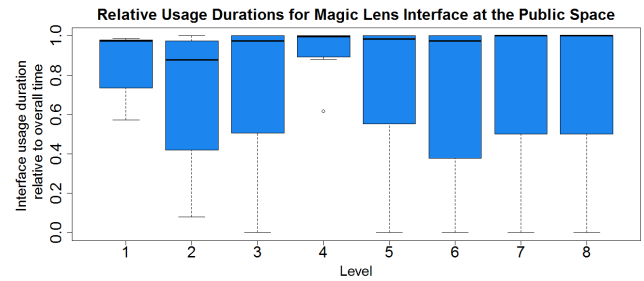


Figure 7. Relative usage duration for the magic lens interface over individual levels in the public setting.

As the mounting of the poster should reflect a possible real-world scene its height was not adjusted to match participants' height. Two small participants held the phone above their heads to reach targets at the top of the poster, one of them eventually switched to the SP mode after 4 levels. Three participants bent their knees regularly to hit targets at the lower half of the poster (see Figure 8).

The phone itself was held in various ways (see Figure 9). One participant switched from portrait to landscape mode to get an overview of the scene and stabilize tracking. Two participants held the phone on the long edge as the phone was more stable when touching it and subsequently tracking errors would be reduced; six held it on the short edge. Six participants held the phone mainly one handed, two used both hands. Two participants eventually used their gloves to hold the phone and changed them between levels due to the weather condition. We could not reliably identify fatigue as a single cause for changing hand poses. The tracking system failed regularly and participants adapted to the tracking system throughout the game. Three participants explicitly mentioned they had changed their hand poses to address tracking errors.

Reasons for Using Magic Lens

A Wilcoxon signed rank test indicated significantly higher ratings for the ML over the SP interface for enjoyment and preference for the public location group (see Table 1).

Questionnaire item	Result	p-value	Z-score
I enjoyed using the ML (MD=5) SP (MD=3) view in the environment	ML>SP	0.036	1.80
I would rather do the task with the ML (MD=5) SP (MD=2) view only	ML>SP	0.029	1.90

Table 1. Questionnaire items that were rated significantly higher for the ML over the SP interface in the public group.

When being asked why the participants who played the game mostly in the ML mode chose to do so, four participants replied that they "liked it more", found it more "groovy", "fun" or just "novel" and "much more interesting". One participant mentioned "I wanted to try out Augmented Reality [ML], as I can use the map [SP] view all the time".

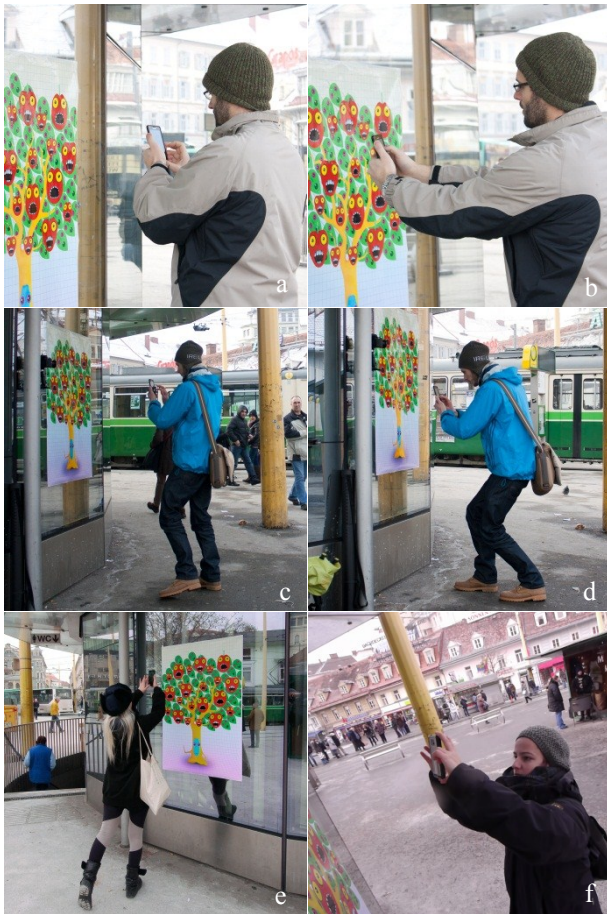


Figure 8. Participant using solely his arms to move back and forth (a, b), bending knees to hit a target at the lower half of the poster (c, d), holding the phone above the head to reach targets at the top of the poster (e, f).

Another participant who used the ML mode exclusively said “I would probably not use it if it would be commonly available”. Two participants explicitly mentioned that they felt being faster in the ML mode. One felt that the music was too attention grabbing in the environment and distracting, turned it off, and continued to play in the ML mode. Another mentioned that with the ML interface “you are much more in the game”. One participant said that she had a better overview in the ML mode and felt it was easier to step back and forth than to pinch-to-zoom. Similarly, another participant said the ML mode was “more intuitive”.

Reasons for Using Static Peephole

While the ML interface was used almost exclusively by 6 of 8 participants in the public setting, two female participants eventually switched to the SP interface completely after 4 and respectively 5 levels. One of them mentioned “I liked that [ML] mode more but switched due to the cold and eventually my hand felt more relaxed”. In the lab condition one participant used the SP interface exclusively as it was “more comfortable” and “not as shaky” as the ML interface. If tracking recovery did not work as expected or took too long participants tended to switch to the SP interface.



Figure 9. Various ways to hold the phone in the magic lens condition: Switching from portrait to landscape mode (a, b), holding the phone across the short or long edge (c, d), using gloves to cope with the cold (e, f, g).

One participant who switched back and forth between the interfaces said: “I wanted to use that [ML] mode but the system [tracking] did not work so I eventually switched to the other [SP] mode and tried again later”. Six participants switched back to the ML interface after playing one level of the game in SP latest. Two participants used ML as overview SP for quickly zooming in and two tried the SP mode to see whether they could be as fast as in ML mode.

Reactions from the Public

We observed reactions from 691 people, who passed by in a half circle of ca. 10 meters around the poster. Approximately every 5 minutes a larger group of 5-10 people simultaneously passed by to change lines. The majority of the passersby did not notice the participants, the poster or the recording equipment at all (68%).



Figure 10. Passersby not noticing the participants interacting with magic lens (left) and static peephole interfaces (right).

Thirty percent of the passersby had short glimpses of less than a second and kept on walking (Figure 11, a). It was not possible to differentiate between the reasons for glimpsing, i.e. whether people looked primarily at the poster, the participant interacting or the wall mounted camera.



Figure 11. Passersby glimpsing (a), watching from a distance (b) and approaching a participant (c).

Ten people (1.5%) stopped and watched for more than 5 seconds (Figure 11, b). In three occasions (0.5%) participants were approached (by one elderly adult, one young adult, group of two boys) and asked what they were doing at the poster. In one occasion the participant explained the game to the children (Figure 11, c).

Detachment from the Environment

The ratings of following items indicated that participants concentrated on the system and tasks (see Figure 12) and did not focus on their environment:

q1: *I concentrated on the system.*

q2: *The tasks took most of my attention.*

Participants also indicated that the environment did not distract them much by rating following items:

q3: *It was hard to concentrate on some targets as I was distracted with the environment.*

q6: *I did not pay attention to the environment when using the ML interface.*

q11: *I was not as aware of time passing or of other people when using the system to complete the tasks, as I feel I would usually be.*

q13: *I felt nervous while using the system.*

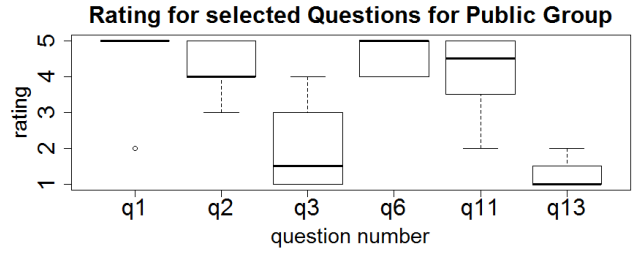


Figure 12. Ratings for selected questions concerning concentration on system and task and distraction by environment (5-point Likert scale, 1: totally disagree, 5: totally agree).

In addition, a Mann-Whitney U test indicated significant differences between the public location and lab group for questionnaire items listed in Table 2. The ratings to the first two items might indicate that even though participants in the public condition were aware of their different role in the environment they did not care about the actions of the surrounding audience. This is also reflected in participants' comments stating that they knew people were around but they did not care about it. The significant lower ratings to the social presence questionnaire item in the last two rows might eventually highlight the fact that users in the public condition played the game in a low temperature environment.

Questionnaire item	Result	p-value	Z-score
I did not pay attention to the environment when using the ML view. (P: MD=5, L: MD=4)	L<P	0.042	-1.72
I was aware that I had a different role in being there than most people in the environment. (P: MD=5, L: MD=4)	L<P	0.002	-2.91
I would rather do the task with the ML view only (P: MD=5, L: MD=3)	L<P	0.039	-1.77
I had to look away from the screen to perform the task (P: MD=1, L: MD=2)	L>P	0.013	2.24
How did you feel using the system in the environment? Cold ... Warm (P: MD=2, L: MD=4)	L>P	<.0001	3.24
How did you feel using the system in the environment? Insensitive ... Sensitive (P: MD=4, L: MD=2, 3)	L<P	0.035	-1.81

Table 2. Questionnaire items that were rated significantly different between the public location (P) and lab (L) group.

During the interviews one participant described the gaming experience as "asocial". She felt "totally focused on the game" and did not pay attention to passersby at all as she "did not care about anything else". Another comment was: "The people watch and see that you are doing something – but actually you are completely passive to your environment"

No Significant Differences in Performance between Lab and Public Group

We included an experimental phase similar to the one described in [10]. We wanted to investigate possible effects of location and audience on task performance. This separate phase was conducted as participants had the free choice on interface usage in the main game phase. The main game phase was not used to analyze task performance. Mann-Whitney U tests indicated no significant differences between the groups for the TCTs or error rates in ML and SP mode (see Table 3 and Table 4).

	Public	Lab
ML	M=50.2 SD=22.3	M=58.5 SD=22.6
SP	M=43.3 SD=10.3	M=43.0 SD=11.1

Table 3. Task completion times (seconds) over 4 levels in performance phase.

	Public	Lab
ML	M=0.31 SD=0.53	M=0.78 SD=1.18
SP	M=0.38 SD=0.71	M=0.31 SD=0.64

Table 4. Selection errors over 4 levels in performance phase.

Using the Interfaces Outside of the Study Setting

Only half of the participants at the public location indicated that they would use the ML interface outside of the study setting at a public transportation stop (see Figure 13). Figure 14 shows in front of which audience the participant would use the interfaces. The questionnaire is similar to the one employed in [22]. According to pairwise Chi-Squared tests of independence there were no significant differences between groups for location or audience ratings. The public group would use the SP interface in public transportation significantly more often ($\chi^2=6.25$, $p=0.012$).

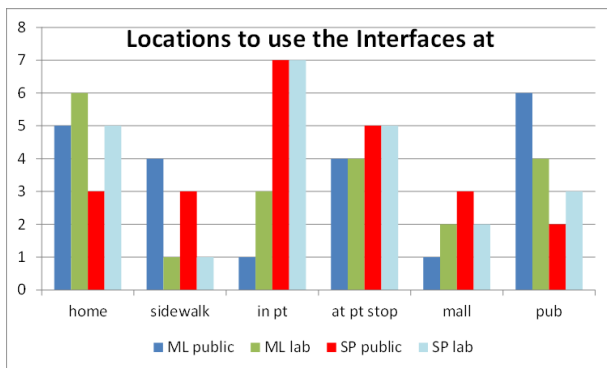


Figure 13. Number of participants who would use the interfaces at various locations (pt: public transportation).

While Yate's continuity correction was applied for addressing the low expected cell count the sample size of 16 items in a 2x2 table should be taken into account when interpreting these results. During the interviews participants further explained their decisions and two mentioned that

they would use the interface specifically with friends around.

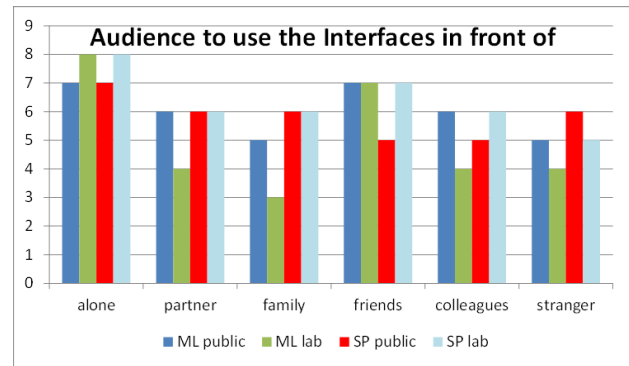


Figure 14. Number of participants who would use the interfaces in front of various audiences.

DISCUSSION

The study demonstrated that, contrary to our expectations, the ML interface was used in the field most of the time; with only few significant differences when compared to laboratory usage. The use of the ML interface was at least partly driven by curiosity as most participants were already familiar with the SP interface and perceived the study as an opportunity to "try out" a new mobile AR game. The novelty of the interface was also indicated by the diverse ways participants handled the phone.

The SP interface was mainly used when the system could not recover from tracking errors fast enough or when participants did not want to move closer to the poster but rather zoomed in to hit the small targets. The levels did not increase in difficulty to ensure we could study fatigue and learning effects. However, we could not uniquely identify individual causes for changing user behavior (especially hand poses). This might be partly due to reoccurring tracking errors being a confounding factor in this study and needs further consideration. Contrary to previous studies about the use of ML and SP interfaces in handheld systems outside the laboratory [17] we used a game design that demanded the attention of single users and had no collaborative aspects. In this study we found no significant effects of location and audience on user behavior and task performance. Participants concentrated mostly on the game task and did not pay attention to passersby and activities going on around them in the street. This finding is supported by other studies where for example, mobile AR users bump into lampposts while engrossed in the screen interface [18] and is a commonly identified problem with pedestrians using their mobile phones and walking out into traffic.

While the ML interface was used by participants most of the time during the study, only half of them indicated they would continue to do so if they had the opportunity to play a game at an augmented poster at a public transport stop in the future. However, the indicated non-game-playing attitudes of the participants need to be taken into account when considering these responses.

Despite confounding factors such as a public space, cold weather and a repetitive task, most users continued to use the ML interface. While the two interfaces were designed to balance the achievable performance and ease the mental gap when switching views, participants' comments indicated that the game could just be less engaging in the SP interface. Overall, the fact that the ML interface was used for an overwhelming percentage of the interaction time requires more exploration.

The majority of passersby did not pay attention to the participants interacting with the poster; if they did then only for a short period of time. As one participant mentioned playing the game in ML mode "is comparable of hearing loud music in public transportation. ... If users do not care about that they might probably also use this [ML] interface". Our observations within this study indicate that for a public transit place interacting with a ML interface does to a large extent not result in socially conspicuous behavior. The observations complement recent online surveys that indicate a small but growing number of users adapting to novel interactive systems, such as QR code equipped products [6] or mobile AR browsers [7] [20] through their smartphones in public spaces.

An open question concerning well-designed augmented posters might be: would people continue to use the ML interface once they become familiar and the novelty has worn off? Our study indicates that at least reactions from the public might not inhibit the initiation of ML usage. Furthermore, "Playing with friends" was a motivating factor mentioned in the interviews to use a ML interface in public when participants would not use that interface alone. Therefore, enabling group activities on augmented posters might lower the barrier for initiating interactions with the ML interface further.

CONCLUSION

We presented a field study on the use of magic lens and static peephole interfaces in a game-like setting at a public transit place. The magic lens interface was used significantly longer and was preferred by participants over the static peephole interface. The audience on the public space mainly did not pay attention to the participants interacting and participants themselves did feel isolated from their environment. A comparison to a control group in a laboratory setting did reveal only few differences despite extenuating circumstances such as weather conditions and the transit nature of the space itself.

In future work we want to conduct the same study at more public locations, particularly those that afford social interactions (e.g., mall, train station) and distribute mobile Augmented Reality games through advertising campaigns in our local cities. We would then collect system usage data remotely, similar to the approach of Henze et al. described in [12]. Further, we want to develop a mobile Augmented Reality game that invites multiple players to collaboratively solve tasks at public posters to investigate potential effects of and on the audience. Finally, we want to examine how to

combine complementary views in the magic lens and static peephole interfaces and switch readily between these in transitional interfaces to enable useful and engaging interfaces depending on the users' context.

ACKNOWLEDGMENTS

This work is made possible by the Austrian National Research Funding Agency FFG in the SmartReality project.

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